Insect relations of certain Asclepiads. II.

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On the ground of usefulness to Asclepias, butterflies may be thrown into three divisions. The Papilios are the most useful, and pollinia were found on all of our species except Ajax. They suck with their wings in motion. Using their legs to offset the motion of the wings, they rapidly repeat those movements which are necessary to draw the pollinia from the anther cells and insert them into the stigmatic chambers. Other large butterflies, like Danais, hold their wings still in sucking, spending more time on an umbel, but generally carrying pollinia. Small butterflies are worse than useless. They remain long on the umbels, sucking, but resting their feet superficially on the flowers, and seldom effecting pollination. Of twenty-three species bearing pollinia, only three are smaller than Chrysophanus Hypophleas; while of twelve species on which no pollinia were found, with the exception of Eudamus Tityrus, which was not caught, the Chrysophanus is the largest. As stated before, butterflies have corpuscula on their claws less frequently than Hymenoptera.

Since several moths were found entrapped on the flowers, pollination must often be brought about by night-flying Lepidoptera.

As a rule, Diptera either do not transfer pollinia at all, or become hopelessly entangled when they do. I have specimens of Eristalis, Trichopoda and Sarcophaga with several pollinia. In contrast with Bembex, mentioned above, certain flies, which resemble wasps in form and colors, also imitate them in their movements on the flowers and extract pollinia more readily than other flies. These are Physocephala, Conops and Midas. The legs of Midas clavatus sometimes bristle with pollinia of A. verticillata and incarnata. Corpuscula were found on the pulvilli, hairs and tongues of flies, never on their claws.

Beetles which visit the flowers to gnaw, as Tetraopes, are injurious, while those visiting them for nectar, Trichius, Euphoria and Chauliognathus, are quite as useful as any flies.

Among Hemiptera, Podisus, which frequents the flowers

to prey upon insects, and Lygaeus, which sucks the hoods regularly, both transfer pollinia.

It is evident that the flowers of Asclepias are adapted to fasten corpuscula upon the legs of insects, and that they catch the tongues only accidentally. However, I have found corpuscula on the tongues of one species of butterfly, two species of beetles, five flies, and twenty Hymenoptera.[10] Bees and wasps move about with their tongues partly extended, and it is natural, especially on the smaller flowers, that some of the appendages which they bear should be caught by the wings. Moreover, combinations of corpuscula are found on the tongues showing that pollination has been effected repeatedly in this way. I have a specimen of Bombus vagans with five corpuscula on tongue, one of B. Virginicus, with a combination of four corpuscula and one single corpusculum, and a Sphex with a combination of five corpuscula. In general, however, extraction of pollinia by the tongue appears to be of little or no use.

ACERATES LONGIFOLIA.—If we compare a flower of this plant with one of Asclepias, it will be apparent that the flowers are not particularly adapted to fasten their corpuscula on the legs of insects (fig. 3).[11] The hoods have no horn, and their tips are pressed against the gynostegium so as to close them. The angles of the wings, instead of being set between the bases of the hoods, are above them. The hoods, therefore, have the sole function of nectaries, and do not serve, as in Asclepias, to guide the legs over the slits.

The anther wings, from the corpusculum to the angle, measure hardly one millimetre, and are adapted to catch fine hairs, not the coarser processes.

Bumble-bees insert their tongues into the closed nectaries with great facility. They are the most common visitors, and the flowers seem to be especially adapted to them. A bumble-bee clasps several flowers between its legs, and, as it moves over the umbel, the abundant hairs on the under side of the thorax, abdomen and basal joints of the legs enter the slits and draw out the pollinia; so that the ventral surface of the bee fairly bristles with them. Fig. 4 is a sketch of Bombus scutellaris, showing the positions of attachment of the corpuscula. The specimen from which it was drawn has more than one hundred pollinia, with many corpuscula which have lost their pollinia, and is not an uncommon case. Hive-bees sometimes visit the flowers. On one I found thirty-three pol-

[10] Hildebrand found pollinia of A. Cornuti on tongues of bees. Bot. Zeit., 1866, No. 48.

[11] The figure references are to plate xii, issued with the September number.

linia, on another fifty-four. I have also found a pair of pollinia on a hair of the abdominal brush of Megachile. Next in abundance to bumble-bees, is Bembex nubillipennis, which rests so lightly on the flowers and has such short hairs that I have failed to find pollinia upon it, except in one case, mentioned below. One beetle, Trichius piger, caught on a Pycnanthemum, has eight corpuscula and eight pollinia on ventral surface. Butterflies rarely force their thin tongues into the nectaries, but do not extract the pollinia. Flies were not seen sucking.

In Acerates viridiflora, the tips of the hoods rise to the level of the style-table, while in this species they hardly reach to the angles of the wings, and it is interesting to observe the effect. In sucking, the insect's head is brought down so close to the tips of the hoods that the hairs on its face and tongue are often caught by the wings; indeed, it seems more natural for visitors of this Acerates to have pollinia on their tongues than for those of Aclepias. Pollinia were found on the hairs of the labrum and tongue of Bombus separatus, and on the labrum of Bembex nubillipennis. Fig. 5, a sketch of the face of Cerceris bicornuta, indicates the positions of attachment of three corpuscula with five pollinia. The specimen also has pollinia on the tongue, and five corpuscula with eight pollinia on ventral surface.

I have seen no combinations of pollinia of this plant, and it does not seem to need them, as it can attach an abundance of corpuscula directly to the hairs.

The pollinia turn with their blades parallel in about a minute after extraction. When the bee moves over the flowers a retinaculum with its pollinium is caught as the hair was before. When the pollinium has entered the stigmatic chamber and will go no further, the retinaculum is broken, leaving the pollinium in the cavity, and escapes from the slit without withdrawing the corpusculum at the top. That the corpusculum does not enter the chamber, but that each pollinium is inserted singly, I am satisfied is true in this plant as well as in Asclepias. It is hardly possible to see pollination effected, as in Asclepias Sullivantii, but I have found pollinia under conditions which indicate that they are introduced in the same manner. A pollinium is sometimes found in the stigmatic chamber with pollen tubes emitted, with its retinaculum projecting through the slit, and the corpusculum and the other pollinium hanging outside. Broken hairs in the cleft of the corpusculum show that it has lost its hold on

the insect, instead of the retinaculum breaking and leaving the pollinium behind. Mansel Weale found pollinia of *Xysmalobium linguæforme* Harv., attached to the long hairs of the sternum and coxæ of a Pallasoma, but they gain this position accidentally, the flower being adapted to fasten pollinia to some part of the insect's head.[12]

Insects with short hairs sometimes suck without drawing out the pollinia, which shows the importance of those with long hairs (bumble-bees).

In all fifteen species of the following genera were caught on the flowers, those bearing pollinia having been mentioned: *Hymenoptera:* Apis, Bombus (2), Megachile (2), Polistes, Odynerus, Cerceris (2), Bembex, Myzine. *Coleoptera:* Trichius. *Lepidoptera:* Thecla, Chrysophanus, Scepsis.

ACERATES VIRIDIFLORA.—The flowers are much larger than in the preceding. The wings measure about one and three-fifths millimetres from the angle to the top, and are adapted to catch the hairs of the legs of insects, not the claws or ventral hairs.

The hoods extend from the bases of the petals to the tips of the anthers, are pressed close to the gynostegium, and are about five millimetres deep.

The pollinia are two and three-fifths millimetres long, and are narrowed above for about half their length into a slender stock. From above the stock is devoid of pollen grains for about one millimetre. The retinacula are very short, serving mainly to keep the pollinia apart, so that both may not be drawn into the same fissure. The stock of the pollinium serves the place of a retinaculum, and lets the granular part of the mass down below the angle of the wings. When drawn up this slender part is caught by the wings, as the hair bearing the corpusculum was before. The base of the mass is drawn into the chamber, and is wedged fast. Then the retinaculum separates from the pollinium, leaving it behind with the long caudicle projecting beyond the anthers. After insects have visited the flowers the presence of a pollinium in the chamber is indicated by this stalk. Sometimes the corpusculum loses its hold on the insect, when we find the pollinia in the condition shown in fig. 6, one with its base emitting tubes, and the corpusculum and other pollinium outside. While the stalk seems to be very useful in effecting pollination, it seems to act injuriously in every case in which a corpus-

[12] "Observations on the mode in which certain species of Asclepiadeæ are fertilized." *Jour. Linn. Soc.*, xiii, 52.

culum is present at the top of the slit, for it enters the cleft and carries the corpusculum up out of its proper position, as shown in fig. 7 (plate xii). Such cases may be found on flowers which insects have visited. Combinations of pollinia can hardly be formed.

Compared with other Asclepiads we have studied, this shows a few peculiarities which we may sum up: (1) The upper part of the pollinium serves the purpose of a retinaculum and is without pollen grains. (2) The pollinium does not fit the stigmatic chamber, but, when in a position to emit tubes has its upper end projecting above the style-table. (3) The retention of the pollinium is effected by its own thickness, and not by a rigid part of the retinaculum which remains attached to it.

I have five specimens of Bombus separatus and three of B. scutellaris, all with pollinia on hairs of legs.

While the hoods of the species of Acerates do not enable them to catch the hairs and pollinia with the same precision as in Asclepias, they compensate for this by restricting the visitors to the most diligent bees, which are provided with an abundance of long hairs.

There are some peculiarities in the adaptations of Asclepiads, which may be brought out by comparing them with ordinary flowers, or with the orchids. If an insect inserts its tongue into the nectary of a Habenaria, it is fairly certain that it will draw out one or both pollinia, and, when sucking another flower, will bring the pollen in contact with the stigma. In the case of Asclepias the most efficient visitor may suck the hoods without drawing out a pollinium, and, then, the chances of a particular pollinium being inserted are not many. Pollination is only fairly certain when the leg is provided with many pollinia. The accidental nature of pollination is to a certain extent conducive to cross fertilization. If we suppose that an insect visits a number of plants, a given pollinium will be more likely to be carried to a distinct plant.

One act of pollination supplies enough pollen to produce good fruit. Mr. Corry has observed that one pollinium is sufficient to fertilize a flower of Asclepias Cornuti.[13]

There are two ways bees have of treating loose pollen, to which the pollinia of Asclepiads are not liable: (1) It is

[13] Trans. Linn. Soc., Lond., Bot 2d, Ser., II, 196. This bears directly on what I have insisted upon, that the pollinia are inserted singly by the knees, and not in pairs by their corpuscula.

well known that they wipe loose pollen from the hairy surface of their bodies to apply it to their pollen collecting apparatus. (2) I have seen Bombus vagans, after visiting several flowers of Triosteum perfoliatum, stop and brush the pollen from her face and tongue without placing it in her corbicula. Bombus Pennsylvanicus was seen to insert her tongue between the introrse anthers of Dodecatheon Meadia, and then hang with her four posterior feet fixed to the flowers and wipe off the pollen with her front legs simply to get rid of it. In contrast with this I have seen bumble-bees trying in vain to free themselves of the pollinia of Acerates longifolia, by which they were evidently annoyed.

As far as the mere application of pollen to an insect is concerned, a flower with loose pollen has the advantage. But the advantage is on the side of Asclepias after the insect is loaded with it. It is only a general rule that insects keep to flowers of a particular species, on their honey and pollen-gathering expeditions. If a bee dusted with loose pollen visits flowers of another species, it will not long retain pollen in sufficient quantity to effectually fertilize flowers of the original species. On the other hand, if an insect returns at any time during the day, or even after a few days,[14] to the species of Asclepias from which it got a load of pollinia, it may bring with it all or most of the pollinia which it has carried from the first plants. The firmness with which the pollinia keep their hold on the insect is one of the best adaptations for cross-fertilization.

Since different species are in bloom at the same time, it is necessary to be very certain that the pollinia on an insect belong to the plant on which it is found. A Scolia caught on Asclepias verticillata had pollinia of this plant and of A. Cornuti on its tarsal hairs. A Papilio found on A. Cornuti had only pollinia of A. tuberosa. A specimen of Bombus scutellaris shows how insects change flowers and emphasizes the advantage in the structure of the pollen-masses of Asclepiads. Its pollen baskets show the yellow pollen of the Petalostemon on which it was caught, and dark pollen from some other plant; and it has, besides, pollinia of Acerates longifolia on ventral surface and of A. viridiflora on hairs of tibiæ. It is interesting to observe that, while the loose pollen was packed in the corbicula to be carried away and left in the

[14] Pollinia of Asclepias Sullivantii, which were extracted and exposed to the air on June 23, were inserted into the stigmatic chambers on July 7, two weeks after extraction, and emitted pollen tubes.

nest, the pollinia of the two Acerates kept their proper position. Now, when such insects visit flowers of the species to which the pollinia belong, full fertilization may take place—cross-fertilization, too, since they have wandered so far from the original plants.

The modifications of the floral structure of different species enable the plants to avoid competition for the same insects, or for the same parts of the same insects. Thus, bumble-bees have pollinia of Asclepias Sullivantii on their claws, of A. verticillata on their tarsal hairs, and of Acerates longifolia on the hairs of the ventral surface.

As an interesting peculiarity of Asclepiads may be mentioned, the occurrence of pollinia in positions in which the flowers are not specially adapted to place them. It has been observed that Asclepias sometimes fastens pollinia on the tongues of insects. Acerates longifolia accidentally catches the hairs of the face and tongue. In contrast with the Acerates, is Xysmalobium linguæforme, whose pollinia, according to Mansel Weale,[15] are found regularly on the insect's head, but only accidentally on the hairs of the tarsi and ventral surface.

BRIEFER ARTICLES.

"Indicative" Eriogonums.—The mountains of Montana are not very high, but they are numerous, extending over a large portion of the territory. Almost wherever prospected they yield precious metals, in some form or other, to the eager searcher after wealth. Even the plains have been found to hide within their vast expanses valuable iron ores and coal.

In the August GAZETTE certain "indicative plants" were spoken of. Eriogonum ovalifolium was considered indicative of silver ore in the soil. We have at least three species of the genus in northern Montana, and I am prepared to state that none of them are indicative of anything of the kind. In 1885, Dr. Frank Pottle, in company with the writer, found a large vein of magnetic iron ore in the Belt mountains. The ore also contained small per cents. of copper and silver. Thickly covering the surface soil of this "lead" were large beds of Eriogonum umbellatum in an unusual degree of luxuriance. It was towards the end of June, and the many creamy-flowered umbels were at their best. It is highly probable that had some knowing old prospector hunting "signs" as well as gold

[15] Loc. cit., p. 52.